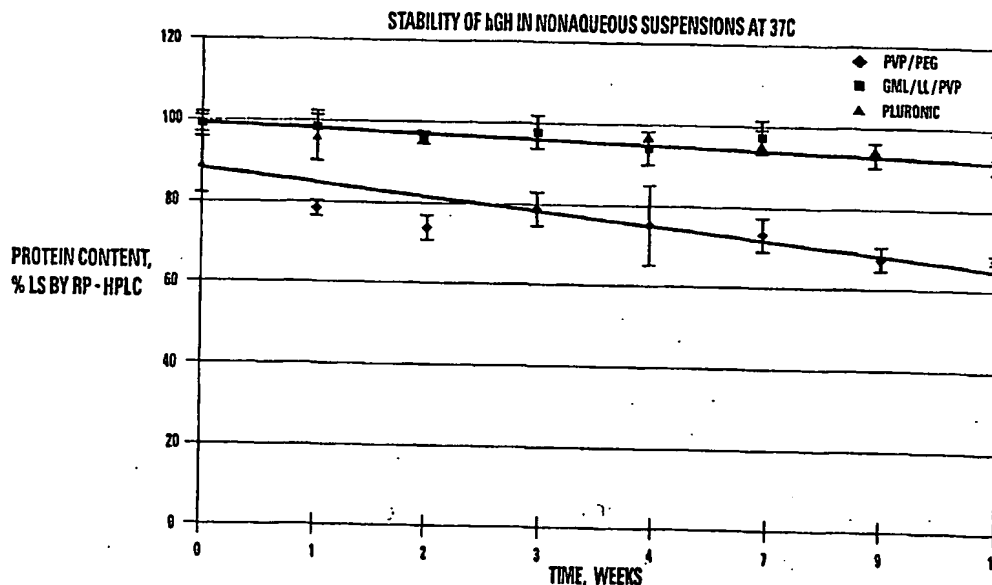




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>A61K 9/10</b>		<b>A2</b>	(11) International Publication Number: <b>WO 00/45790</b>
			(43) International Publication Date: 10 August 2000 (10.08.00)
(21) International Application Number: <b>PCT/US00/02772</b> (22) International Filing Date: <b>2 February 2000 (02.02.00)</b> (30) Priority Data: 60/119,170                      8 February 1999 (08.02.99)                      US (71) Applicant: <b>ALZA CORPORATION [US/US]; 1900 Charleston Road, P.O. Box 7210, Mt. View, CA 94039-7210 (US).</b> (72) Inventors: <b>BERRY, Stephen, A.; 1050 Spring Grove Road, Hollister, CA 95023 (US). FERREIRA, Pamela, J.; 304 Canoe Court, Redwood City, CA 94065 (US). DEHNAD, Houdin; 507 Vallejo Street, El Granada, CA 94018-1325 (US). MUCHNIK, Anna; 1542 Winding Way, Belmont, CA 94002 (US).</b> (74) Agents: <b>CLARKE, Pauline, Ann et al.; Alza Corporation, 1900 Charleston Road, P.O. Box 7210, Mt. View, CA 94039-7210 (US).</b>		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>Without international search report and to be republished upon receipt of that report.</i>	

(54) Title: STABLE NON-AQUEOUS SINGLE PHASE VISCOUS VEHICLES AND FORMULATIONS UTILIZING SUCH VEHICLES



## (57) Abstract

This invention relates to stable non-aqueous single phase viscous vehicles and to formulations utilizing such vehicles. The formulations comprise at least one beneficial agent uniformly suspended in the vehicle. The formulation is capable of being stored at temperatures ranging from cold to body temperature for long periods of time. The formulations are capable of being uniformly delivered from drug delivery systems at an exit shear rate of between about 1 to  $1 \times 10^7$  reciprocal second.

BEST AVAILABLE COPY

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

## STABLE NON-AQUEOUS SINGLE PHASE VISCOUS VEHICLES AND FORMULATIONS UTILIZING SUCH VEHICLES

5

### Field of the Invention

This invention relates to stable non-aqueous single phase biocompatible viscous vehicles capable of suspending beneficial agents and uniformly dispensing said agents at low flow rates and more particularly to stable uniformly mixed formulations of beneficial agents in stable non-aqueous single phase biocompatible viscous vehicles.

### References

The following references are referred to by numbers in brackets ([ ]) at the relevant portion of the specification.

- 15 1. Wang, et al., *J. Parenteral Sci. Tech*, **42**: S4-S26 (1988).
2. Desai, et al., *J. Am. Chem. Soc.*, **116**: 9420-9422 (1994).
3. Chang, et al., *Pharm. Tech.*, 80-84 (Jan. 1996).
4. Manning, et al., *Pharm. Res.*, **6**: 903-918 (1989).
5. Hageman, *Drug Dev. Ind. Pharm*, **14**: 2047-2070 (1988).
- 20 6. Bell, et al., *Biopolymers*, **35**: 201-209 (1995).
7. Zhang, et al., *Pharm. Res.* **12**: 1447-1452 (1995).
8. PCT published application 98/00158
9. PCT published application 98/16250
10. Knepp, et al., *Pharm. Res.* **15** (7) 1090-1095 (1998).
- 25 11. PCT published application 98/00157
12. PCT published application 98/00152
13. U.S. Patent 5,540,912
14. U.S. Patent 5,571,525
15. U.S. Patent 5,512,293
- 30 16. PCT published application 96/40049
17. Yu, et al., *J. Pharm. Sci.*, **85**: 396-401 (1996).

18. Mitchell, U.S. Patent No. 5,411,951 (1995).
19. Brooks, et al., U.S. Patent No. 5,352,662 (1994)
20. Geller, L., U.S. Patent No. 3,869,549 (1975).
21. Larsen, et al., PCT Publication No. WO95/34285 (1995).
- 5 22. Knepp, et al., *J. Pharm. Sci. Tech*, **50**: 163-171 (1996).
23. U.S. Patent 5,614,221
24. U.S. Patent 4,594,108
25. U.S. Patent 5,300,302
26. U.S. Patent 4,588,614
- 10 27. U.S. Patent 4,310,516
28. U.S. Patent 5,635,213
29. EP 379,147

#### Background of the Invention

15       Peptides, polypeptides, proteins and other proteinaceous substances (e.g., viruses, antibodies) collectively referred to herein as proteins, have great utility as pharmaceuticals in the prevention, treatment and diagnosis of disease. Proteins are naturally active in aqueous environments, thus the preferred formulations of proteins have been in aqueous solutions. However, 20 proteins are only marginally stable in aqueous solutions. Thus, protein pharmaceuticals often have short shelf-lives under ambient conditions or require refrigeration. Further, many proteins have only limited solubility in aqueous solutions. Even when they are soluble at high concentrations, they are prone to aggregation and precipitation.

25       Because proteins can easily degrade, the standard method for delivering such compounds has been daily injections. Proteins can degrade via a number of mechanisms, including deamidations of asparagine and glutamine; oxidation of methionine and, to a lesser degree, tryptophan, tyrosine and histidine; hydrolysis of peptide bonds; disulfide interchange; and 30 racemization of chiral amino acid residues [1-7]. Water is a reactant in nearly

all of these degradation pathways. Further, water acts as a plasticizer, which facilitates unfolding and irreversible aggregation of proteins. Since water is a participant in almost all protein degradation pathways, reduction of aqueous protein solution to a dry powder provides an alternative formulation methodology to enhance the stability of protein pharmaceuticals.

One approach to stabilizing proteins is to dry them using various techniques, including freeze-drying, spray-drying, lyophilization, and desiccation. Dried proteins are stored as dry powders until their use is required.

A serious drawback to drying of proteins is that often one would like to use proteins in some sort of flowable form. Parenteral injection and the use of drug delivery devices for sustained delivery of drug are two examples of the applications where one would like to use proteins in a flowable form. For injection, dried proteins must be reconstituted, adding additional steps which are time-consuming and where contamination may occur, and exposing the protein to potentially destabilizing conditions [7]. For drug delivery devices the protein formulations must be stable for extended periods of time at body temperature and maintain their flowability for the expected life of the device.

Solution formulations of proteins/peptides in non-aqueous polar aprotic solvents such as DMSO and DMF have been shown to be stable at elevated temperatures for long periods of time [8]. However, such solvent based formulations will not be useable for all proteins since many proteins have low solubility in these solvents. The lower the solubility of the protein in the formulation, the more solvent would have to be used for delivery of a specific amount of protein. Low concentration solutions may be useful for injections, but may not be useful for long term delivery at low flow rates.

Proteins have been formulated for delivery using perfluorodecalin [9, 10], methoxyflurane [9], high concentrations in water [11], polyethylene glycol [12], PLGA [13, 14], ethylenevinylacetate/polyvinylpyrrolidone mixtures [15], PEG400/povidone [16]. However, these formulations were not shown to

retain a uniform suspension of protein in viscous vehicle over long periods of time.

Many biologically active compounds degrade over time in aqueous solution. Carriers in which proteins do not dissolve but rather are suspended, can often offer improved chemical stability. Furthermore, it can be beneficial to suspend the beneficial agent in a carrier when the agent exhibits low solubility in the desired vehicle. However, suspensions can have poor physical stability due to settling and agglomeration of the suspended beneficial agent. The problems with non-aqueous carriers tend to be exacerbated as the concentration of the active compound is increased.

Dispersing powdered proteins or peptides in lipid vehicles to yield parenteral sustained release formulations has been investigated [17-21]. The vehicles used were either various vegetable (sesame, soy, peanut, etc.) or synthetic oils (e.g., Miglyol) gelled with aluminum fatty acid esters such as aluminum stearates (mono-, di- or tri-), or with a polyglycerol ester. Although theoretically these vehicles might preclude solution denaturation and protect the drug from aqueous chemical degradation, the vehicles themselves are unstable at higher temperatures. The storage of liquid vegetable oils at body temperatures results in the formation of reactive species such as free fatty acids and peroxides (a process which is accelerated by the presence of traces of various metal ions such as copper or iron which can leach from some implantable devices). These peroxides not only adversely affect protein stability [22] but would be toxic when delivered directly to, for example, the central nervous system of a human or animal.

The sustained delivery of drugs has many advantages. Use of implantable devices assures patient compliance, since the delivery device is tamper-proof. With one insertion of a device, rather than daily injections, there is reduced site irritation, fewer occupational hazards for practitioners improved cost effectiveness through decreased costs of equipment for repeated injections, reduced hazards of waste disposal, and enhanced

efficacy through controlled release as compared with depot injection. The use of implantable devices for sustained delivery of a wide variety of drugs or other beneficial agents is well known in the art. Typical devices are described, for example, in U.S. Patents Nos. 5,034,229; 5,057,318; 5,110,596; and 5,782,396. The disclosure of each of these patents is incorporated herein by reference.

For drug delivering implants, dosing durations of up to one year are not unusual. Beneficial agents which have low therapeutic delivery rates are prime candidates for use in implants. When the device is implanted or stored, settling of the beneficial agent in a liquid formulation can occur. This heterogeneity can adversely affect the concentration of the beneficial agent dispensed. Compounding this problem is the size of the implanted beneficial agent reservoir. Implant reservoirs are generally on the order of 25-250  $\mu$ l, but can be up to 25 ml.

Viscous formulations have been prepared using two separate components to be mixed with drug at use [23], thickening agents added to aqueous compositions [24], gelling agents added to aqueous drug solutions [25], porous textile sheet material [26], thickening agents with oleaginous material [27], viscous aqueous carrier for limited solubility drug [28], and extrudable elastic gels [29]. However, these formulations are mixed at use, contain aqueous components, use sheet matrices, or are delivered topically, orally, or intraduodenally.

Stability of formulations can be enhanced by freeze-drying, lyophilizing or spray-drying the active ingredient. The process of drying the active ingredient includes further advantages such as compounds which are relatively unstable in aqueous solution can be processed and filled into dosage containers, dried without elevated temperatures, and then stored in the dry state in which there are relatively few stability problems.

Pharmaceutical formulations, particularly parenteral products, should be sterilized after being sealed in the final container and within as short a time

as possible after the filling and sealing have been completed. (See, for example Remington, Pharmaceutical Sciences, 15<sup>th</sup> ed. (1975)). Examples of sterilization techniques include thermal or dry-heat, aseptic, and ionized radiation. Combinations of these sterilization procedures may also be used to  
5 produce a sterile product.

There is a need to be able to deliver protein compositions to the body which are stable at body temperatures over extended periods of time to enable long term delivery of the protein. There is a need to be able to deliver concentrations of proteins that are efficacious. There is a need for a novel  
10 non-aqueous formulation capable of homogeneously suspending proteins and dispensing such agents at body temperatures and low flow rates over extended periods of time.

#### Summary of the Invention

15 The present invention provides stable single phase non-aqueous biocompatible viscous vehicles capable of forming uniform suspensions with proteins. The components of the viscous vehicle comprise at least two of polymer, surfactant, and solvent. The ratios of the components will vary depending on the molecular weight of the components and the desired  
20 viscosity of the final vehicle. Presently preferred component ratios are: polymer, about 5% to about 60%; solvent, about 30% to about 50%; and surfactant, about 5% to about 20%.

The present invention also provides stable formulations in which beneficial agents are uniformly suspended in stable single phase non-  
25 aqueous biocompatible viscous vehicles. In particular, the beneficial agents are formulated in the viscous vehicles at concentrations of at least about 0.1%, depending upon the potency of the beneficial agent. These stable formulations may be stored at the temperature appropriate for the beneficial agent, ranging from cold, to body temperature (about 37°C) for long periods of  
30 time (1 month to 1 year or more). In a preferred embodiment the formulation



comprises about 0.1 to 50% (w/w) of beneficial agent, depending on the potency of the beneficial agent, the duration of treatment, and the rate of release for the drug delivery system.

These formulations are especially useful in implantable delivery  
5 devices for long term delivery (e.g., 1 to 12 months or longer) of beneficial agent at body temperature, preferably about 37°C. Thus, the present invention also provides for the delivery of said proteins to the body over extended period of time to enable long term delivery of the protein at low flow rates of about 0.3 to 100  $\mu$ l/day, preferably about 0.3 to 4  $\mu$ l/day for about a 6  
10 month delivery period and preferably 5 to 8  $\mu$ l/day for about a 3 month delivery period.

In another aspect, the invention provides methods for preparing stable non-aqueous biocompatible formulations of a beneficial agent in a single phase viscous vehicle. Preferred formulations comprise about 0.1 to 50%  
15 (w/w) beneficial agent depending on the potency of the beneficial agent, the duration of treatment, and the rate of release from the delivery system.

In yet a further aspect, the invention provides methods for treating a subject suffering from a condition which may be alleviated by administration of a beneficial agent, said methods comprising administering to said subject an  
20 effective amount of a stable non-aqueous formulation comprising at least one beneficial agent uniformly suspended in a single phase viscous vehicle.

A further aspect of the invention is that non-aqueous single phase viscous vehicles containing beneficial agents are chemically and physically stable over a broad temperature range for long periods of time. The beneficial  
25 agents in the viscous vehicles are also chemically and physically stable over a broad temperature range for long periods of time. Thus, these formulations are advantageous in that they may be shipped and stored at temperatures below, at, or above room temperature for long period of time. They are also suitable for use in implantable delivery devices in which the formulation must  
30 be stable at body temperature for extended periods of time.

The formulations of the present invention also remain stable when delivered from implantable drug delivery systems. The beneficial agents have been shown to exhibit zero order release rates when delivered from implantable drug delivery systems at very low flow rates over extended periods of time.

#### Brief Description of the Drawings

Figure 1 shows the stability of hGH formulations of the present invention as determined at 37°C by reverse phase HPLC.

Figure 2 shows the stability of hGH formulations of the present invention as determined at 37°C by size exclusion chromatography.

Figure 3 shows the average release rate ( $\mu\text{l/day}$ ) of 10% (w/w) spray-dried lysozyme in formulations of the present invention.

Figure 4 shows the average release rate ( $\mu\text{l/day}$ ) of 10% (w/w) spray-dried hGH in a glycerol monolaurate/lauryl lactate/polyvinylpyrrolidone vehicle.

Figure 5 shows the average release rate ( $\mu\text{g/day}$ ) of 10% lysozyme in a lauryl alcohol/polyvinylpyrrolidone vehicle.

Figure 6 shows the average release rate ( $\mu\text{g/day}$ ) of 25% lysozyme in a glycerol monolaurate/lauryl lactate/polyvinylpyrrolidone vehicle.

Figure 7 shows the average release rate ( $\mu\text{g/day}$ ) of 33% lysozyme in a glycerol monolaurate/lauryl lactate/polyvinylpyrrolidone vehicle.

Figure 8 shows the average release rate ( $\mu\text{g/day}$ ) of 45% lysozyme in a glycerol monolaurate/lauryl lactate/polyvinylpyrrolidone vehicle.

#### Detailed Description of the Invention

The present invention is drawn to the unexpected discovery that uniformly suspending beneficial agents in non-aqueous single phase biocompatible viscous vehicles results in stable formulations which can be delivered at body temperature over an extended period of time at low flow

rates. Previously known formulations of beneficial agents which are buffered aqueous or non-aqueous solutions which may or may not contain excipients do not provide formulations which can be uniformly dispensed at body temperatures at low flow rates over an extended period of time without  
5 exhibiting unacceptable amounts of aggregation or degradation of the formulation. The presently claimed formulations stabilize beneficial agents and can be stored at the temperature appropriate for the beneficial agent. The temperatures can range from cold (not exceeding 8°C) to body temperature (about 37°C) for long periods of time. These formulations are  
10 especially useful in implantable delivery devices for long term delivery (e.g., 1 to 12 months or longer) of drug at low flow rates and at body temperature, preferably about 37°C.

Standard beneficial agent formulations consist of dilute aqueous or non-aqueous solutions or suspensions. Drug stability is usually achieved by  
15 varying one or more of the following: pH, buffer type, ionic strength, excipients (EDTA, ascorbic acid, etc.) For these formulations, degradation pathways requiring water (hydrolysis, deamidation, racemization) cannot be fully stabilized. In the present invention, beneficial agents formulated in non-aqueous biocompatible single phase viscous vehicles containing for example,  
20 polyvinylpyrrolidone, vinyl acetate, and/or polyoxyethylenepolyoxypropylene block copolymers were shown to be chemically and physically stable. The viscosity of the formulation will depend upon a number of criteria, including the beneficial agent potency and concentration, and the process by which the formulation is prepared. The viscosity of the formulation can be chosen so  
25 that the desired amount of beneficial agent is delivered over the desired period of time.

The invention also consists of non-aqueous single phase biocompatible viscous vehicles capable of uniformly suspending beneficial agents and formulations containing at least one beneficial agent uniformly suspended in  
30 said viscous vehicle. The invention also consists of formulations containing at

least one beneficial agent uniformly suspended in a non-aqueous single phase biocompatible viscous vehicle, which formulations are stable for an extended period of time at body temperatures, and capable of delivering said beneficial agents uniformly at low flow rates. The discovery consists of the realization that stable non-aqueous viscous vehicles improve the stability of beneficial agents in a wide range of formulation conditions including concentration, elevated temperatures and duration of stable formulation, thus making possible the delivery of beneficial agents in long term implantable devices that would not otherwise be feasible.

#### Definitions

As used herein, the following terms have the following meanings:

The term "chemical stability" means that an acceptable percentage of degradation products produced by chemical pathways such as oxidation, deamidation, or hydrolysis is formed. In particular, a formulation is considered chemically stable if no more than about 35% breakdown products are formed after 2 months at 37°C.

The term "physical stability" means that an acceptable percentage of aggregates (e.g., dimers, trimers and larger forms) are formed by the beneficial agent. For the formulation (viscous vehicle and beneficial agent) this term means that the formulation retains stability, flowability, and the ability to uniformly dispense the beneficial agent. In particular, a formulation is considered physically stable if no more than about 15% aggregates are formed after two months at 37°C.

The term "stable formulation" means that at least about 65% chemically and physically stable beneficial agent remains after two months at 37°C (or equivalent conditions at an elevated temperature). Particularly preferred formulations are those which retain at least about 80% chemically and physically stable beneficial agent under these conditions. Especially preferred

stable formulations are those which do not exhibit degradation after sterilizing irradiation (e.g., gamma, beta or electron beam).

The term "beneficial agent" means peptides, proteins, nucleotides, hormones, viruses, antibodies, etc. that comprise polymers of amino acid or nucleic acid residues. These beneficial agents are generally degradable in water and generally stable as a dry powder at elevated temperatures.

Synthetically produced, naturally derived or recombinantly produced moieties are included in this term. The term also includes lipoproteins and post translationally modified forms, e.g., glycosylated proteins. Analogs, derivatives, agonists, antagonists and pharmaceutically acceptable salts of any of these are included in this term. The term also includes proteins and/or protein substances which have D-amino acids, modified, derivatized or non-naturally occurring amino acids in the D- or L- configuration and/or peptomimetic units as part of their structure. The term protein will be used in the present invention. The term also means that the beneficial agent is present in the solid state, e.g., powder or crystalline.

The term "excipient" means a more or less inert substance in a formulation that is added as a diluent or vehicle or to give form or consistency. Excipients are distinguished from solvents such as ETOH, which are used to dissolve drugs in formulations. Excipients include non-ionic surfactants such as polysorbates, which are used to solubilize drugs in formulations; preservatives such as benzyl alcohols or methyl or propyl parabens, which are used to prevent or inhibit microbial growth; chelating agents; flavoring agents; and other pharmaceutically acceptable formulation aides.

The term "viscous vehicle" means a vehicle with a viscosity in the range of about 1,000 to 10,000,000 poise. The term includes Newtonian and non-Newtonian materials. Preferred are vehicles with a viscosity of about 10,000 to 250,000 poise. The formulations of this invention can uniformly expel beneficial agents suspended in the viscous vehicle from implantable drug delivery devices. The formulations exhibit a shear rate at the exit of said

devices of 1 to  $1 \times 10^{-7}$  reciprocal second, preferably an exit shear rate of  $1 \times 10^{-2}$  to  $1 \times 10^{-5}$  reciprocal second.

The term "single phase" means a solid, semi-solid, or liquid homogeneous system that is both physically and chemically uniform throughout as determined by differential scanning calorimetry (DSC). The DSC scan should show one peak indicative of a single phase.

The term "biocompatible" means a property or characteristic of a viscous vehicle to disintegrate or break down, over a prolonged period of time, in response to the biological environment in the patient, by one or more physical or chemical degradative processes, for example by enzymatic action, oxidation or reduction, hydrolysis (proteolysis), displacement, e.g. ion exchange, or dissolution by solubilization, emulsion or micelle formation, and which material is then absorbed by the body and surrounding tissue, or otherwise dissipated thereby.

The term "polymer" includes polyesters such as PLA (polylactic acid) [having an inherent viscosity in the range of about 0.5 to 2.0 i.v.] and PLGA (polylacticpolyglycolic acid) [having an inherent viscosity in the range of about 0.5 to 2.0 i.v.], pyrrolidones such as polyvinylpyrrolidone (having a molecular weight range of about 2,000 to 1,000,000), esters or ethers of unsaturated alcohols such as vinyl acetate, and polyoxyethylenepolyoxypropylene block copolymers (exhibiting a high viscosity at 37°C) such as Pluronic 105. Currently preferred polymer is polyvinylpyrrolidone.

The term "solvent" includes carboxylic acid esters such as lauryl lactate, polyhydric alcohols such as glycerin, polymers of polyhydric alcohols such as polyethylene glycol (having a molecular weight of about 200 to 600), fatty acids such as oleic acid and octanoic acid, oils such as castor oil, propylene carbonate, lauryl alcohol, or esters of polyhydric alcohols such as triacetin acetate. Currently preferred is lauryl lactate.

The term "surfactant" includes esters of polyhydric alcohols such as glycerol monolaurate, ethoxylated castor oil, polysorbates, esters or ethers of

saturated alcohols such as myristyl lactate (Ceraphyl 50), and polyoxyethylenepolyoxypropylene block copolymers such as Pluronic. Currently preferred are glycerol monolaurate and polysorbates.

The term "antioxidant" means a pharmaceutically acceptable aid for  
5   stabilization of the beneficial agent against degradation such as oxidation. Antioxidants include, but are not limited to, tocopherol (vitamin E), ascorbic acid, ascorbyl palmitate, butylated hydroxyanisole, butylated hydroxytoluene, and propyl gallate. A preferred antioxidant depends on solubility and the  
10   change of the beneficial agent in the preferred vehicle. Currently preferred is ascorbyl palmitate.

#### Preparation of Formulations

The present invention is drawn to stable non-aqueous single phase  
15   biocompatible viscous vehicles capable of suspending beneficial agents and uniformly dispensing said beneficial agents at body temperatures at low flow rates over an extended period of time. The present invention is also directed to formulations containing beneficial agents uniformly suspended in said single phase biocompatible viscous vehicles which are stable for prolonged  
20   periods of time at body temperatures.

Examples of beneficial agents that may be formulated using the present invention include those peptides or proteins that have biological activity or that may be used to treat a disease or other pathological condition. They include, but are not limited to, adrenocorticotrophic hormone, angiotensin  
25   I and II, atrial natriuretic peptide, bombesin, bradykinin, calcitonin, cerebellin, dynorphin N, alpha and beta endorphin, endothelin, enkephalin, epidermal growth factor, fertirelin, follicular gonadotropin releasing peptide, galanin, glucagon, GLP-1, gonadorelin, gonadotropin, goserelin, growth hormone releasing peptide, histrelin, human growth hormone, insulin, interferons,  
30   leuprolide, LHRH, motilin, nafarerlin, neurotensin, oxytocin, relaxin,

somatostatin, substance P, tumor necrosis factor, triptorelin, vasopressin, growth hormone, nerve growth factor, blood clotting factors, ribozymes, and antisense oligonucleotides. Analogs, derivatives, antagonists agonists and pharmaceutically acceptable salts of the above may also be used.

5           The beneficial agents useful in the formulations and methods of the present invention can be used in the form of a salt, preferably a pharmaceutically acceptable salt. Useful salts are known to those of skill in the art and include salts with inorganic acids, organic acids, inorganic bases, or organic bases.

10           Beneficial agents that are not readily soluble in non-aqueous solvents are preferred for use in the present invention. One of skill in the art can easily determine which compounds will be useful on the basis of their solubility. The amount of beneficial agent may vary depending on the potency of the compound, the condition to be treated, the solubility of the compound,  
15 the expected dose and the duration of administration. (See, for example, Gilman, et. al, The Pharmacological Basis of Therapeutics, 7<sup>th</sup> ed. (1990) and Remington, Pharmacological Sciences, 18<sup>th</sup> ed. (1990), the disclosures of which are incorporated herein by reference.)

          It has been unexpectedly found that using a stable non-aqueous single  
20 phase biocompatible viscous vehicle increases the stability of the beneficial agent. For example, as seen in Figures 1 and 2, human growth hormone (hGH) was found to be stable at 37°C over 12 weeks in formulations of polyvinylpyrrolidone/PEG; Pluronic; and glycerol monolaurate/lauryl lactate/  
polyvinylpyrrolidone. Figure 1 shows stability results using reverse phase  
25 HPLC. Figure 2 shows stability results using size exclusion chromatography.

          Generally, stable non-aqueous single phase biocompatible viscous vehicles may be prepared by combining the dry (low moisture content) ingredients in a dry box or under other dry conditions and blending them at elevated temperature, preferably about 40 to about 70°C, to allow them to  
30 liquify. The liquid vehicle is allowed to cool to room temperature. Differential



scanning calorimetry was used to verify that the vehicle was single phase. The final moisture content of the viscous vehicle was <2%.

Generally, the stable formulations of the present invention may be prepared by combining the vehicle and beneficial agent under dry conditions and blending them under vacuum at elevated temperature, preferably about  
5 40 to about 70°C, to disperse the beneficial agent uniformly throughout the vehicle. The formulation is allowed to cool to room temperature.

It has been found that drying the beneficial agent prior to formulation enhances the stability of the formulation.

10 It has also been found that adding antioxidants, such as tocopherol, ascorbic acid, ascorbyl palmitate, butylated hydroxyanisole, butylated hydroxytoluene, and propyl gallate reduces the formation of degradation products (e.g., unstable chemical intermediates) during sterilization.

#### 15 Methodology

We have found that stable non-aqueous beneficial agent formulations utilizing viscous vehicles may be prepared by combining the ingredients for the viscous vehicle under dry conditions and blending them at elevated temperature to allow them to liquify and form a single phase. Once a single  
20 phase viscous vehicle is formed, the vehicle is allowed to cool to room temperature. Beneficial agent is added with mixing at elevated temperature under vacuum to uniformly disperse it in the viscous vehicle.

We have tested these beneficial agent formulations, for example formulations of hGH, for stability by subjecting them to accelerated aging  
25 tests. Results show that these formulations remained stable over extended periods of time.

We have tested beneficial agent formulations, for example human growth hormone and lysozyme, for stability by suspending them in a variety of non-aqueous single phase viscous vehicles prepared according to the present  
30 invention, then subjecting them to accelerated aging at elevated

temperatures. The stability of the formulations was measured. Results of these studies demonstrate that these formulations were stable at conditions that approximate or exceed storage for one year at 37°C.

We have also tested beneficial agent formulations prepared as described herein for stability after 2.5 megarads gamma irradiation. Results show that these formulations remained chemically and physically stable after such irradiation.

### Methods

The following methods were used to perform the studies in the Examples that follow.

#### 1. Preparing Protein powders

Human Growth Hormone (obtained for example, from BresaGen Limited, Adelaide, Australia)

The active agent was reconstituted in deionized water. The solution containing the active agent was buffer exchanged using an Amicon Diaflo® Ultrafiltration membrane (molecular weight cut-off 10,000).

The diafiltrated active agent solution was spray dried using a Yamato mini-spray dryer. Powder was collected in a collection vessel through a cyclone trap. All handling of the spray dried powder took place in a dry box evacuated with nitrogen. The generated powder was analyzed for particle size and distribution, moisture content, protein content and stability by size exclusion and reverse-phase chromatography.

It is known that the conformation of some proteins can be stabilized by the addition of a sugar (such as sucrose or mannitol) or a polyol (such as ethylene glycol, glycerol, glucose, and dextran.)

#### 2. Preparation of Viscous Vehicles

We have found that stable single phase biocompatible viscous vehicles may be prepared by combining the ingredients and blending them at elevated temperatures to allow them to liquify and form a single phase. A differential

scanning calorimetry scan showed one peak, indicative of a single phase. The mixing was completed under vacuum to remove trapped air bubbles produced from the powders. The mixer was a dual helix blade mixer (D.I.T.) which runs at a speed around 40 rpm. Higher speeds can be used but are not required.

If a three component viscous vehicle is prepared, the solvent portion of the vehicle was added to the heated bowl of the mixer first, followed by the surfactant. The polymer was added last, and the ingredients were mixed until a solution (single phase) resulted. Vacuum was applied during mixing to remove air bubbles. The solution was dispensed from the bowl while at elevated temperature, and allowed to cool to room temperature. On cooling the vehicle exhibited increased viscosity. Two and single component gels were made using the same process.

### 3. Preparation of beneficial agent formulations

To prepare the formulation, the single phase viscous vehicle was heated and then blended under vacuum with a weighed amount of beneficial agent. The beneficial agent and the single phase viscous vehicle were blended in the same manner as the vehicle was prepared, using a dual helix blade mixer (or other similar mixer). Mixing speed was between 40 and 120 rpm for approximately 15 minutes or until a uniform dispersion was attained. The resulting mixture was removed from the mixer, sealed in a dry container, and allowed to cool to room temperature.

### 4. Preparation of reservoirs

The reservoirs of implantable drug delivery devices (as disclosed in U.S. Patent Application Serial No. 08/595,761, incorporated herein by reference) were filled with the appropriate hGH formulation. The formulation was filled into titanium reservoirs with a polymer plug blocking each end. The filled reservoir was then sealed in a polyfoil bag and placed in a stability testing oven.

It should be noted that the formulations in the reservoirs of these devices are completely isolated from the outside environment.

#### 5. Reverse Phase-HPLC (RP-HPLC)

5 All stability samples of hGH were assayed for protein content and chemical stability by reverse phase chromatography (RP-HPLC). Analyses were performed on a Hewlett Packard HP-1090 system with a refrigerated autosampler (4°C). The chromatographic conditions used are listed below.

10

TABLE 1

#### RP-HPLC Chromatographic Conditions

Description	Parameter																		
Column	J.T. Baker-C18, 4.6x250 mm																		
Flow Rate	1.0 mL/min																		
15 Detection	214 nm																		
Mobile Phase	A: 0.1% TFA in water B: 0.1% TFA in acetonitrile																		
Gradient	<table><tr><th>time</th><th>%A</th><th>%B</th></tr><tr><td>0</td><td>65</td><td>35</td></tr><tr><td>20 5</td><td>50</td><td>50</td></tr><tr><td>45</td><td>35</td><td>65</td></tr><tr><td>50</td><td>30</td><td>70</td></tr><tr><td>55</td><td>65</td><td>35</td></tr></table>	time	%A	%B	0	65	35	20 5	50	50	45	35	65	50	30	70	55	65	35
time	%A	%B																	
0	65	35																	
20 5	50	50																	
45	35	65																	
50	30	70																	
55	65	35																	

25 An hGH reference standard solution was prepared and its protein content calculated from the absorbance measurement at 280 nm. Three dilutions of this solution, representing 80%, 100%, and 120% of the expected concentration of hGH in the samples were run in duplicate at the beginning and the end of each run and used to calculate total protein content of the  
30 samples.

## 6. Size Exclusion Chromatography (SEC)

All stability samples of hGH were assayed for protein content and high  
5 molecular weight degradation products by size exclusion chromatography.

Analyses were performed on a Hewlett Packard HP-1090 system with a  
refrigerated autosampler (4°C). The chromatographic conditions used are  
listed below

10

TABLE 2  
SEC Chromatographic Conditions

	<u>Description</u>	<u>Parameter</u>
	Column	TSK-2000SWXL
15	Flow Rate	0.5 ml/ min
	Detection	214 nm
	Mobile Phase	25 mM sodium phosphate, 100 mM sodium chloride, pH 7.0

20

A hGH reference standard solution was prepared and its protein  
content calculated from the absorbance measurement at 280 nm. Three  
dilutions of this solution, representing 80%, 100%, and 120% of the expected  
concentration of hGH in the samples were run in duplicate at the beginning  
and the end of each run and used to calculate total protein content of the  
25 samples. The amount of high molecular weight degradation products was  
calculated by area normalization.

The following examples are offered to illustrate this invention and are  
not meant to be construed in any way as limiting the scope of this invention.

## EXAMPLE 1

Preparation of Non-aqueous Single Phase Viscous Vehicles

The non-aqueous single phase viscous vehicles can be prepared as follows and shown in the below table

- A. Glycerol monolaurate (Danisco Ingredients, New Century, Kansas) (25 g) was dissolved in lauryl lactate (ISP Van Dyk Inc., Belleville, NJ) (35 g) at 65°C. Polyvinylpyrrolidone C30 (BASF, Mount Olive, NJ) (40 g) was added and the mixture blended at about 40 rpm in a dual helix blade mixer (D.I.T.) until a single phase was achieved. Trapped air bubbles were removed by applying vacuum to the mixing chamber. The single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.
- B. Glycerol monolaurate (Danisco Ingredients, New Century, Kansas) (25 g) was dissolved in lauryl lactate (ISP Van Dyk Inc., Belleville, NJ) (35 g) at 65°C. Polyvinylpyrrolidone C17 (BASF, Mount Olive, NJ) (40 g) was added and the mixture blended at about 40 rpm in a dual helix blade mixer (D.I.T.) until a single phase was achieved. Trapped air bubbles were removed by applying vacuum to the mixing chamber. The single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.
- C. Polyvinylpyrrolidone C30 (BASF, Mount Olive, NJ) (50 g) was dissolved in polyethylene glycol 400 (Union Carbide) (50 g) at approximately 65°C until a single phase solution was formed. The single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.
- D. Polyvinylpyrrolidone C17 (BASF, Mount Olive, NJ) (50 g) was dissolved in polyethylene glycol 400 (Union Carbide) (50 g) at approximately 65°C until a single phase solution was formed. The

single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.

E. Polyvinylpyrrolidone C17 (BASF, Mount Olive, NJ) (50 g) was dissolved in castor oil (Spectrum, Gardena, CA) (50 g) at approximately 65°C until a single phase solution was formed. The single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.

F. Polyvinylpyrrolidone C17 (BASF, Mount Olive, NJ) (50 g) was dissolved in octanoic acid (Spectrum, Gardena, CA) at approximately 65°C until a single phase solution was formed. The single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.

G. Polyvinylpyrrolidone C17 (BASF, Mount Olive, NJ) (50 g) was dissolved in oleic acid (Spectrum, Gardena, CA) at approximately 65°C until a single phase solution was formed. The single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.

H. Polyvinylpyrrolidone C17 (BASF, Mount Olive, NJ) (35%) was dissolved in glycerin (Baker, NJ) (65%) at approximately 65°C until a single phase solution was formed. The single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.

I. Cremophor EL (ethoxylated castor oil) (BASF, Mount Olive, NJ) (5%) was dissolved in castor oil (Spectrum, Gardena, CA) (70%), and polyvinylpyrrolidone C17 (BASF, Mount Olive, NJ) (25%) was added and dissolved by mixing at approximately 40 rpm to form a single phase vehicle. The single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.

J. Pluronic 105 (BASF, Mount Olive, NJ) was heated to approximately 65°C with mixing until melted. The single phase vehicle was dispensed from the mixer, and allowed to cool to room temperature.

Table 3  
Component Ratios

	Component			Viscosity at Low	
	Polymer	Surfactant	Solvent	Ratio	Shear Rate (Poise)
5	PVP	GML	LL	53:5:42	25,000
	PVP	GML	LL	55:10:35	50,000
	PVP	GML	LL	50:15:35	7,000
	PVP	----	LA	60:40	
	PVP	Ceraphyl 50	LA	60:10:30	
10	PVP	----	oleic acid	50:50	30,000
	PVP	----	octanoic acid	55:45	7,000
	PVP	polysorbate 80	----	50:50	
	PVP	----	PEG 400	50:50	
	PVP	caster oil	----	50:50	
15	----	Pluronic 105	----	100	1,000,000
	PVP	----	glycerin	50:50	5,000

Wherein:

- 20 GML = glycerol monolaurate  
 LL = lauryl lactate  
 PVP = polyvinylpyrrolidone C30  
 LA = lauryl alcohol  
 PEG = polyethyleneglycol 400

25

## EXAMPLE 2

### Preparation of hGH

#### A. Preparation by spray drying

30 Lyophilized hGH (BresaGen Limited, Adelaide, Australia) was reconstituted in 150 ml of deionized water. This stock solution contained



1050 mg of hGH. Buffer exchange was accomplished using an Amicon Diaflo® Ultrafiltration membrane (molecular weight cut-off 10,000). The ultrafiltration cell was connected to an auxilliary reservoir containing 5mM phosphate buffer (pH 7). The cell's fluid volume, as well as the hGH  
5 concentration, remained constant as excipients were replaced by phosphate buffer.

The diafiltrated protein solution (protein concentration in the solution approximately 2%) was spray dried using a Yamato mini-spray dryer. Settings on the spray dryer were as follows: aspiration pressure constantly  
10 adjusted to 1.3 kgf/cm<sup>2</sup>, inlet temperature 120°C, solution flow rate 2.5 (approximately 3 ml/min). Powder was collected in a collection vessel through a cyclone trap. All handling of the spray dried powder took place in a dry box evacuated with nitrogen (% RH: 1-4%). The water content of the suspending  
vehicles is shown in the below table.

15

TABLE 4  
WATER CONTENT OF SUSPENDING VEHICLES

Vehicle	Water Content of Vehicle at T 0 % w/w	Water Content of Vehicle in 12 wks. At 37°C % w/w
Pluronic 105	0.25	0.4
GML/LL/PVP	1.5	1.3
25 PVP/PEG	2.0	2.0

Wherein:

GML = glycerol monolaurate

LL = lauryl lactate

30 PVP = polyvinylpyrrolidone C30

PEG = polyethyleneglycol 400

## EXAMPLE 3

## Preparation of hGH Formulation

A portion of the single phase viscous vehicle was weighed (9 g) and  
 5 heated to 60°C. hGH (BresaGen Limited, Adelaide, Australia) (1 g) was  
 added to the vehicle and mixed for 15 minutes. The mixing was completed  
 under vacuum to remove air bubbles added from the powder.

Approximately 10 mg of the spray-dried hGH powder were weighed out  
 (content of hGH in the powder was recalculated based on the determined  
 10 water and salt content) and mixed with 100 µl of the vehicle at 55-65°C (3  
 samples per each vehicle). Special care was taken while mixing powder in  
 the suspending vehicle to achieve maximum particle uniform dispersion in the  
 vehicle. All steps were done in a dry box.

The resulting suspension was dissolved with 10 ml of release rate  
 15 buffer and analyzed by size exclusion and reverse-phase chromatography.  
 Spray dried hGH powder was used as a control.

TABLE 5

20 STABILITY OF hGH SUSPENSIONS AT 37°C AS MEASURED BY  
 SIZE EXCLUSION CHROMATOGRAPHY

	Time Weeks	Spray-dried Powder -80°C %LS	PVP/PEG 400 suspension %LS	GML/LL/PVP suspension %LS	Pluronic 105 suspension %LS
25	0	96±1	88±6	92±2	87±7
	1	99±8	81±2	94±3	93±3
	2	99±3	83±1	97±1	94±1
	3	97±1	84±2	95±2	95±3
30	4	95±2	82±8	94±4	93±5
	7	95±4	76±3	93±4	88±2
	12	97±4	79±3	97±1	95±6

Each data point represents the mean  $\pm$  relative standard deviation of three individual samples taken from three separate vials.

TABLE 6  
STABILITY OF hGH SUSPENSIONS at 37°C AS MEASURED BY  
REVERSE PHASE CHROMATOGRAPHY

Time Weeks	spray-dried Powder -80°C %LS	PVP/PEG 400 suspension %LS	GML/LL/PVP suspension %LS	Pluronic 105 suspension %LS
0	104 $\pm$ 1	99 $\pm$ 3	99 $\pm$ 2	89 $\pm$ 7
1	104 $\pm$ 8	78 $\pm$ 2	98 $\pm$ 3	96 $\pm$ 6
2	104 $\pm$ 4	73 $\pm$ 3	95 $\pm$ 1	96 $\pm$ 1
3	104 $\pm$ 2	78 $\pm$ 4	97 $\pm$ 3	97 $\pm$ 4
4	100 $\pm$ 2	74 $\pm$ 10	93 $\pm$ 4	96 $\pm$ 4
7	108 $\pm$ 5	72 $\pm$ 4	96 $\pm$ 2	94 $\pm$ 2
9	102 $\pm$ 3	66 $\pm$ 3	92 $\pm$ 3	93 $\pm$ 2
12	101 $\pm$ 2	66 $\pm$ 1	89 $\pm$ 2	92 $\pm$ 5

Each data point represents the mean  $\pm$  relative standard deviation of three individual samples taken from three separate vials.

#### EXAMPLE 4

##### Preparation of Reservoirs Release Rate Profiles

Titanium reservoir systems of implantable drug delivery devices (as disclosed in U.S. Patent Application Serial No. 08/595,761, incorporated herein by reference) were each assembled with an osmotic engine, piston, and rate controlling membrane. The reservoirs were filled with the appropriate amount of viscous vehicle formulation and capped with a flow

plug. The systems were placed in a water bath at 37°C, and allowed to release formulation for an extended period of time. Released material was sampled twice per week. Assays for released material were completed using reverse phase HPLC. The resulting concentrations of beneficial agent for each system were converted to released amount per day. The beneficial agent was found to have a zero order release from the implantable drug delivery device. As shown in Figures 3 through 8.

### EXAMPLE 5

#### Stability of hGH in Non-aqueous Viscous Vehicle Formulations

Formulations of 10% w/w hGH in vehicle were prepared as described above and placed in vials. The formulations were subjected to accelerated aging by storing them at elevated temperatures and times shown in the below table in a controlled temperature oven .

TABLE 7

Vehicle	Time(hrs)	Temperature	%LS by SEC	%LS by RP-HPLC
Pluronic 105	0	50°C	98±3	101±3
Pluronic 105	1	50°C	98±3	101±4
Pluronic 105	2	50°C	100±1	102±3
Pluronic 105	4	50°C	101±3	105±3
GML/LL/PVP	0	65°C	99±3	101±3
GML/LL/PVP	1	65°C	93±6	97±6
GML/LL/PVP	2	65°C	91±5	95±5
GML/LL/PVP	4	65°C	95±3	98±3

Each data point represents the mean ± relative standard deviation of three individual samples taken from three separate vials.

Results, presented in the following table, demonstrate that these formulations were able to maintain the stability of the hGH in each case. In each case, at least 70% hGH was retained.

5

TABLE 8

## RECOVERY OF hGH FROM NONAQUEOUS SUSPENSIONS

	<u>Vehicle</u>	<u>%LS by RP-HPLC</u>	<u>%LS by Size-exclusion HPLC</u>
	PVP/PEG 400	99±3%	88±6%
10	GML/LL/PVP	99±2%	92±2%
	Pluronic 105	89±7%	87±7%

Each data point represents the mean ± relative standard deviation of three individual samples taken from three separate vials.

15 %LS or % label strength = (measured protein content + theoretical protein content) x 100%

Modification of the above-described modes of carrying out various embodiments of this invention will be apparent to those of skill in the art following the teachings of this invention as set forth herein. The examples  
20 described above are not limiting, but are merely exemplary of this invention, the scope of which is defined by the following claims.

## Claims:

1. A stable non-aqueous single phase biocompatible viscous vehicle capable of suspending beneficial agents and homogeneously dispensing said beneficial agent over an extended period of time at body temperature and at low flow rates.
2. The vehicle of claim 1 comprising two components selected from the group consisting of solvent, surfactant, and polymer, wherein the two components are not of the same type.
3. The vehicle of claim 1 comprising at least two components selected from the group consisting of solvent, surfactant, and polymer, wherein the components are not of the same type.
4. The vehicle of claim 1 which comprises three components selected from the group consisting of solvent, surfactant, and polymer, wherein the components are not of the same type.
5. The vehicle of claim 2 or 4 wherein said solvent is selected from the group carboxylic acid esters, polyhydric alcohols, polymers of polyhydric alcohols, fatty acids, oils, propylene carbonate, lauryl alcohol, and esters of polyhydric alcohols.
6. The vehicle of claim 2 or 4 wherein said surfactant is selected from the group esters of polyhydric alcohols, ethoxylated castor oil, polysorbates, esters or ethers of saturated alcohols, and polyoxyethylenepolyoxypropylene block copolymers.

7. The vehicle of claim 2 or 4 wherein said polymer is selected from the group polyesters, pyrrolidones, esters or ethers of unsaturated alcohols, and polyoxyethylenepolyoxypropylene block copolymers.

5 8. The vehicle of claim 2 wherein the ratios of the components are in the range of 40:60 to 60:40.

9. The vehicle of claim 4 wherein the ratios of the components are in the range of about 30% to about 50% for solvent, about 5% to about 20% for  
10 surfactant, and about 5% to about 60% for polymer.

10. The vehicle of claim 4 wherein the polymer is polyvinylpyrrolidone, the surfactant is gml, and the solvent is lauryl lactate.

15 11. The vehicle of claim 4 wherein the polymer is polyvinylpyrrolidone, the surfactant is polysorbate, and the solvent is lauryl lactate.

12. The vehicle of claim 1 which comprises an antioxidant.

20 13. The vehicle of claim 12 wherein said antioxidant is selected from the group consisting of tocopherol, ascorbic acid, ascorbyl palmitate, butylated hydroxyanisole, butylated hydroxytoluene, and propyl gallate.

14. A stable non-aqueous viscous protein formulation comprising

- 25 a) at least one beneficial agent, and  
b) a non-aqueous single phase biocompatible viscous vehicle, which formulation is capable of being uniformly dispensed over an extended period of time at a low flow rate.

15. A non-aqueous formulation comprising at least one beneficial agent uniformly suspended in a non-aqueous single phase biocompatible viscous vehicle, which formulation can be delivered from an implantable drug delivery system such that the exit shear rate of the formulation is between about 1 and  
5  $1 \times 10^{-7}$  reciprocal second.

16. The formulation of claim 14 wherein said formulation is stable at body temperature for extended periods of time.

10 17. The formulation of claim 14 which comprises at least about 0.1% (w/w) beneficial agent.

18. The formulation of claim 14 which comprises at least about 10% (w/w) beneficial agent.

15

19. The formulation of claim 14 wherein said beneficial agent is selected from the group consisting of peptide, protein, nucleotide, hormone, virus, or antibody.

20 20. The formulation of claim 19 wherein said beneficial agent is a protein.

21. The formulation of claim 14 which is stable at 65° C for at least about 2 months.

25 22. The formulation of claim 14 which is stable at 37° C for at least about 3 months.

23. The formulation of claim 14 which is stable at 37° C for at least about one year.



24. The formulation of claim 14 which is adapted for use in an implantable drug delivery device.

25. The formulation of claim 14 wherein said vehicle is selected from the  
5 group consisting of solvent, surfactant and polymer.

26. The formulation of claim 14 wherein said vehicle comprises an antioxidant.

10 27. The formulation of claim 14 comprising a beneficial agent which has been dried to a low moisture content prior to incorporation in said formulation.

28. The formulation of claim 14 which is stable after sterilization.

15 29. A method for preparing the stable single phase viscous vehicle of claim 1 comprising the steps of (1) blending the ingredients at elevated temperature under dry conditions to allow them to liquify, and (2) allowing the liquid from step (1) to cool to room temperature.

20 30. A method for preparing the stable formulation of claim 14 comprising combining the single phase viscous vehicle and beneficial agent under dry conditions and blending them under vacuum at elevated temperature to uniformly disperse the beneficial agent in the vehicle, and allowing the formulation to cool to room temperature.

25 31. The method of claim 30 wherein at least about 0.1% (w/w) beneficial agent is suspended in said vehicle.

30 32. The method of claim 30 wherein at least about 10% (w/w) beneficial agent is suspended in said vehicle.

33. A method for treating a subject suffering from a condition which may be alleviated by administration of a beneficial agent comprising administering to said subject a therapeutically effective amount of the formulation of Claim 14.

5

34. The method of claim 33 wherein said administration is parenteral administration.

10

35. The method of claim 33 wherein said administration is long-term continuous administration.

36. The method of claim 33 wherein said administration is accomplished by use of an implantable drug delivery system.

15

37. The method of claim 33 wherein said daily administration continues for a period selected from the group consisting of about 3 months, about 6 months, and about 12 months.

20

38. The method of claim 37 wherein said daily administration is accomplished using an implantable drug delivery system.

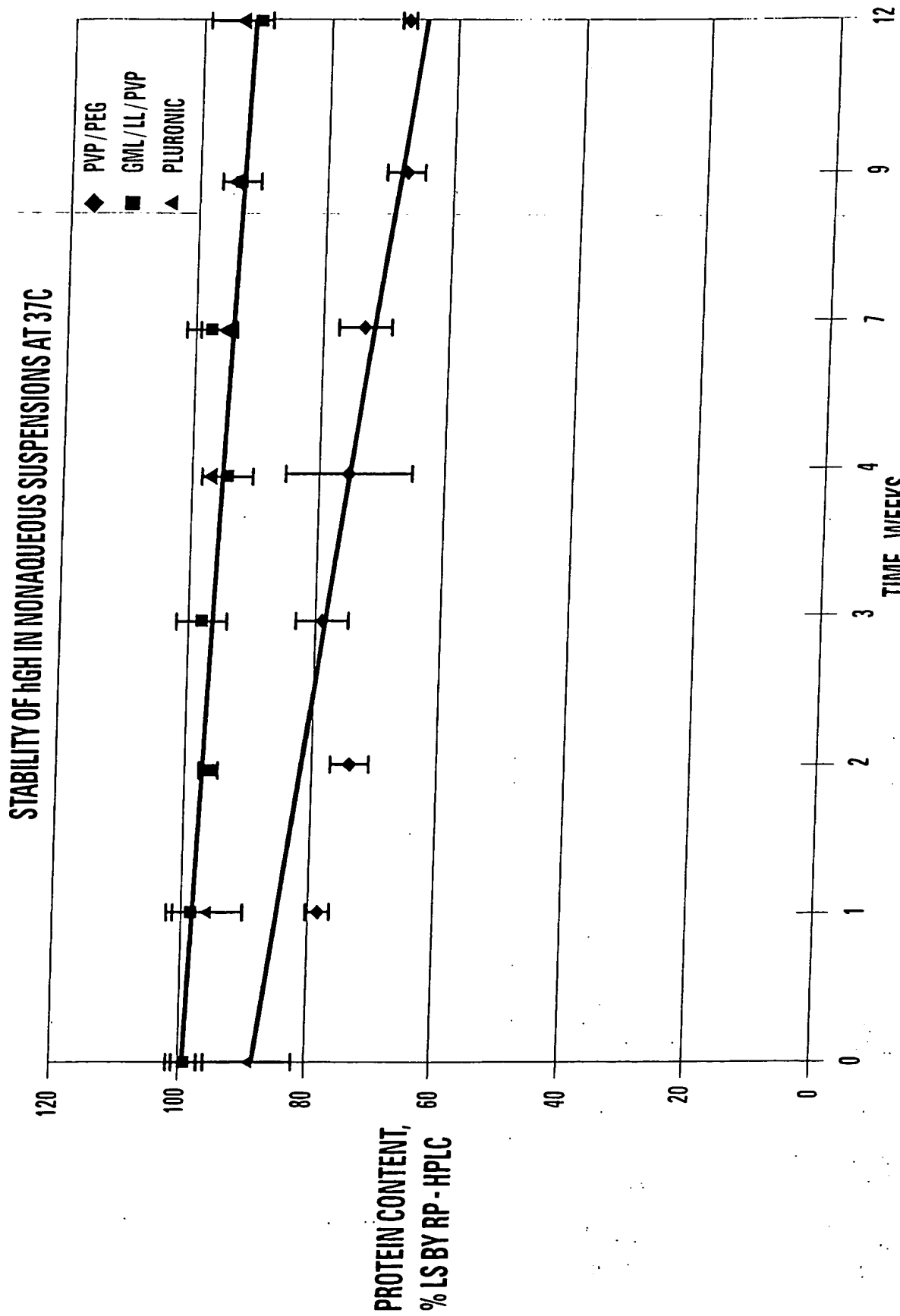


FIGURE 1

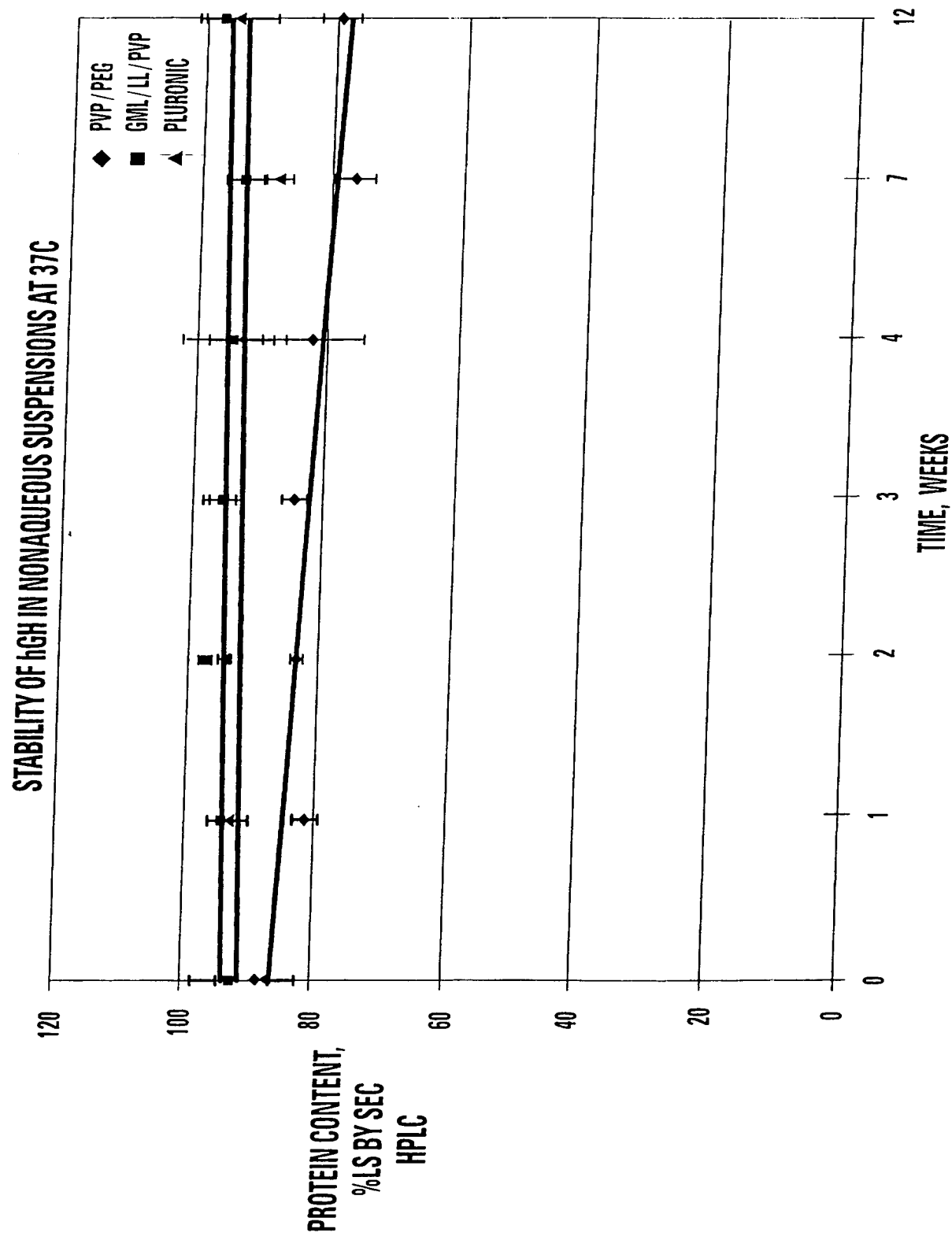
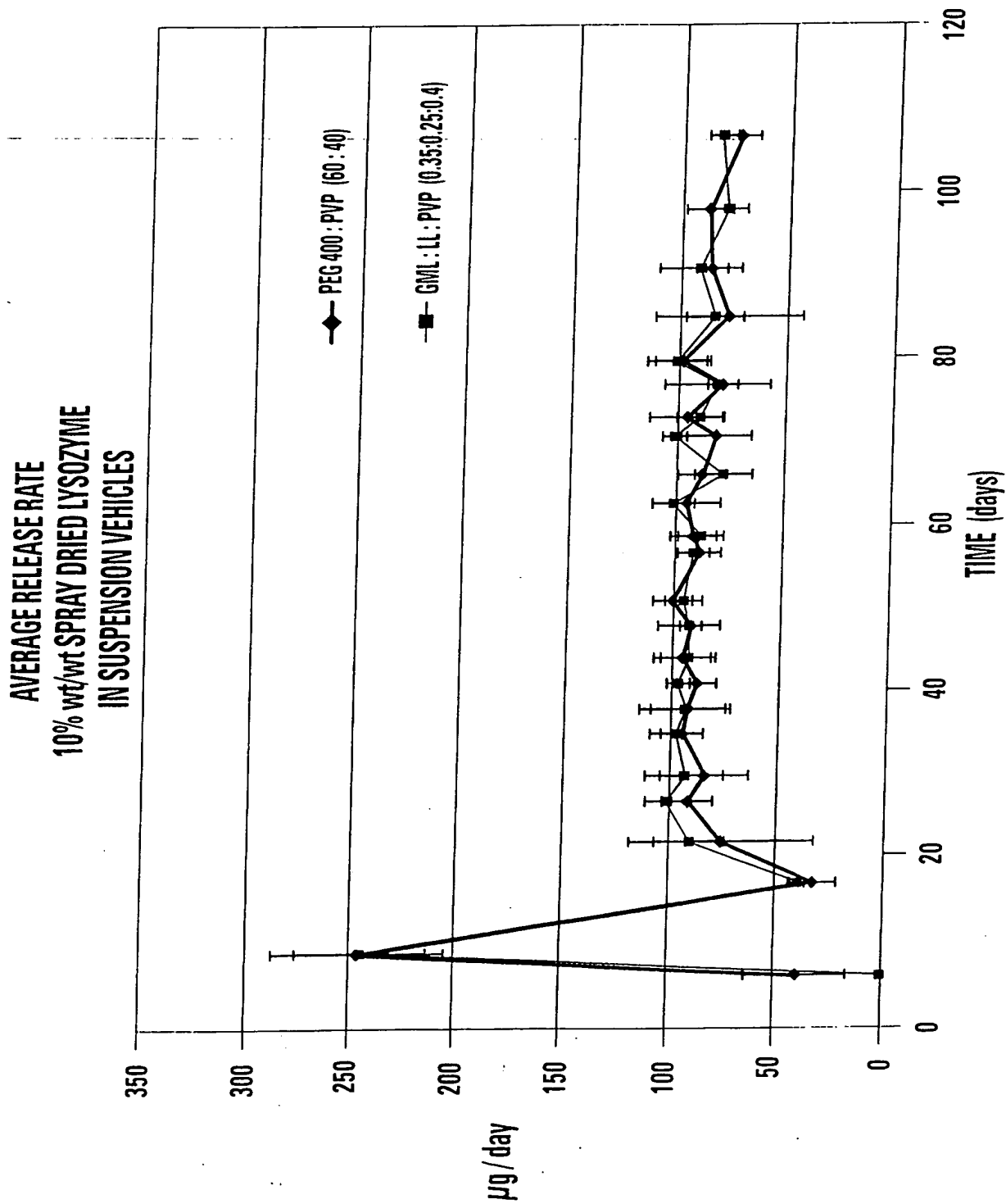


FIGURE 2



**FIGURE 3**

4 / 8

IN VITRO SYSTEMS, PRE-RAT STUDY  
AVERAGE RELEASE RATE ( $\mu\text{g/day}$ )

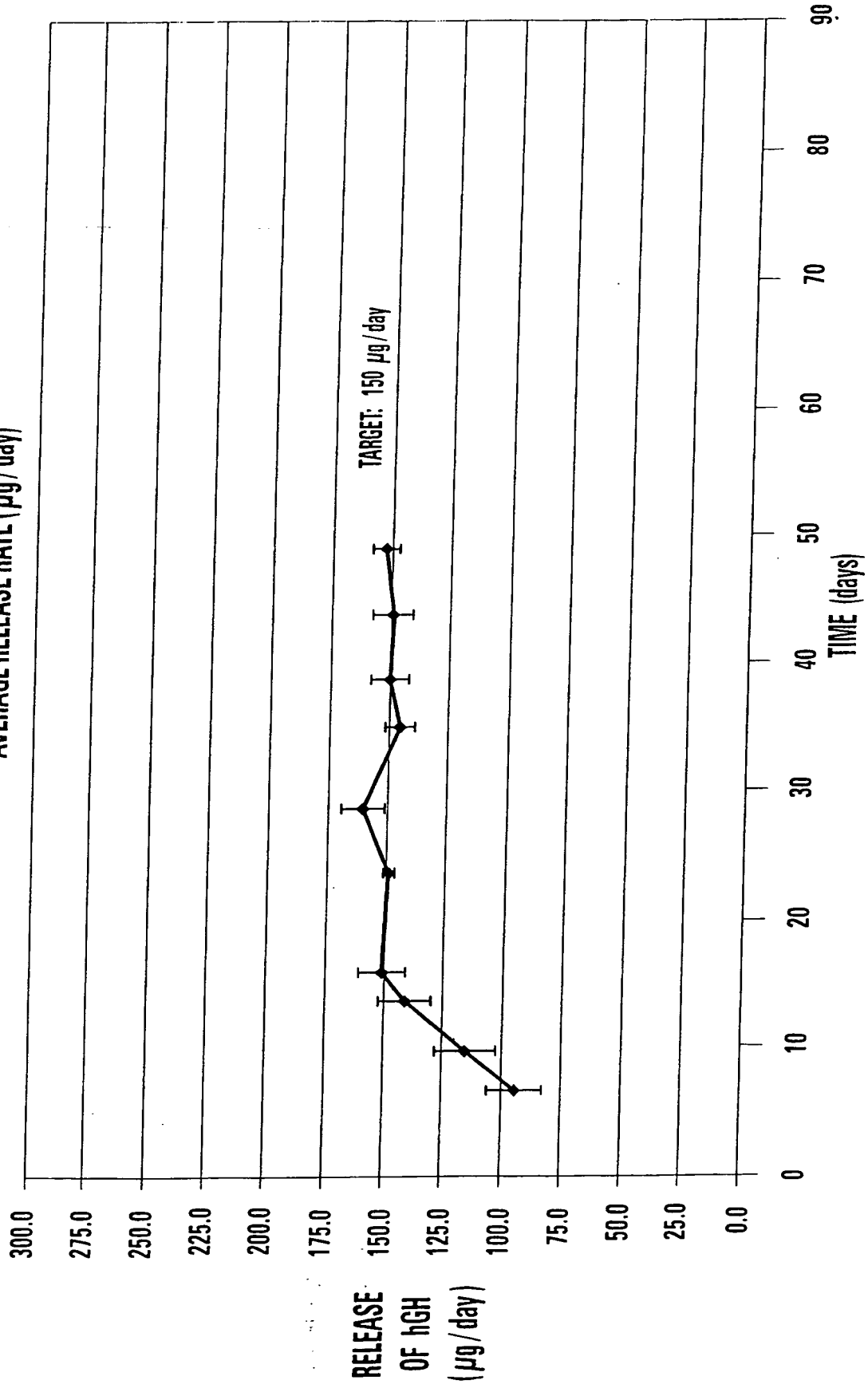
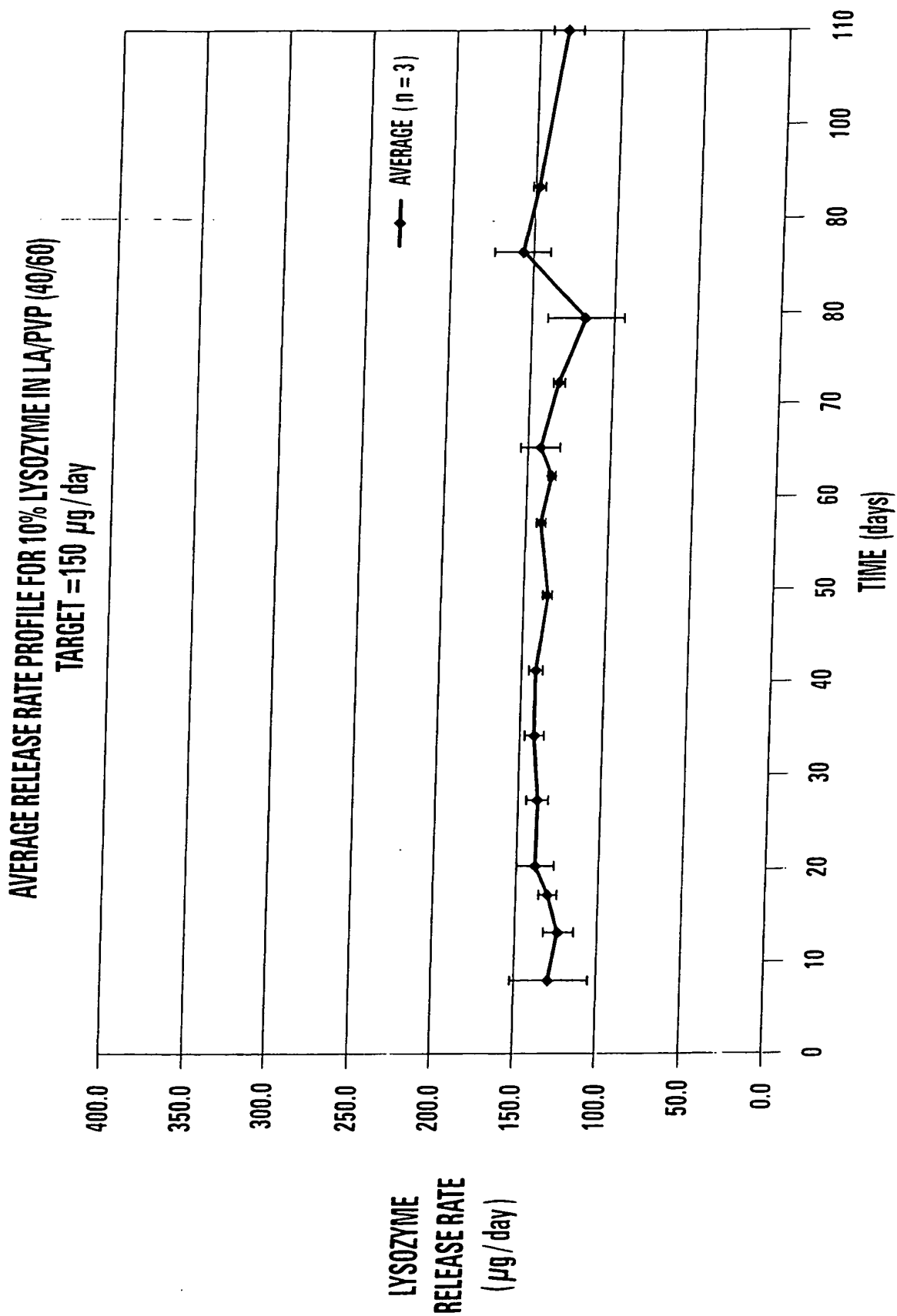


FIGURE 4



**FIGURE 5**

25% LOADED PARTICLES IN GML:LL:PVP VEHICLE  
RELEASE RATE ( $\mu\text{g/day}$ ), n=5

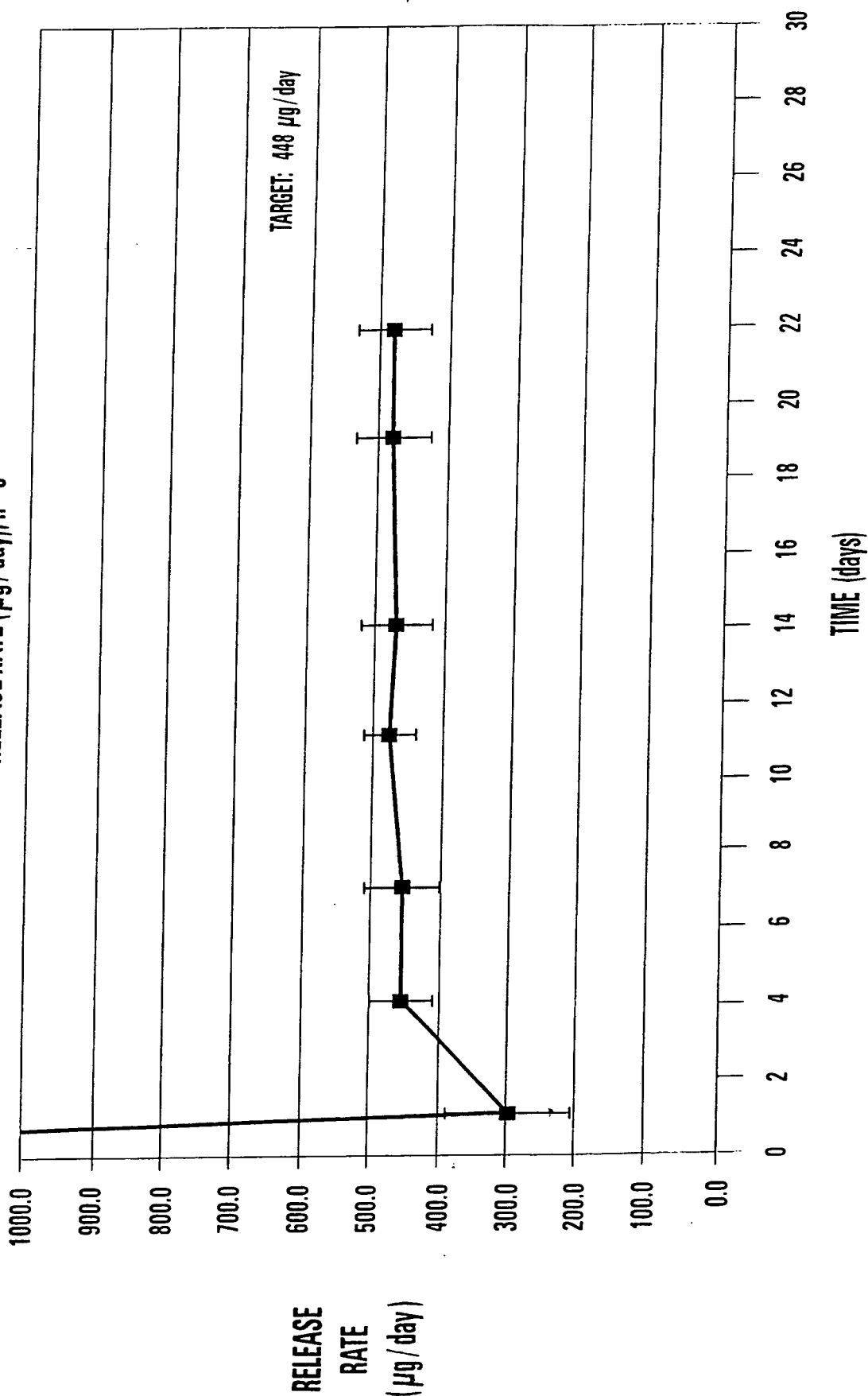


FIGURE 6



33% PARTICLES LOADED VEHICLE GML:LL:PVP  
RELEASE RATE ( $\mu\text{g/day}$ ),  $n=4$

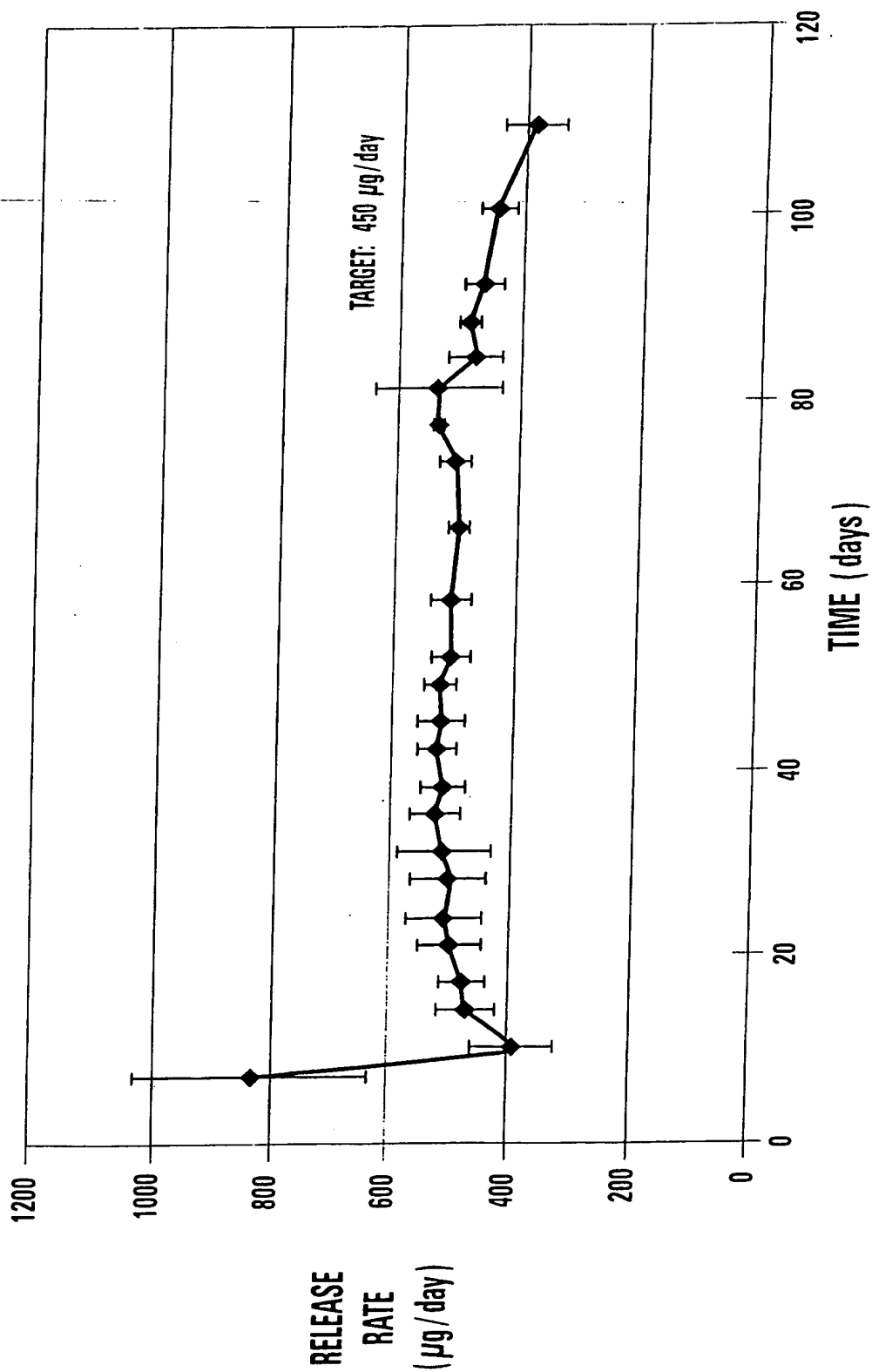


FIGURE 7

8 / 8

45% LOADED PARTICLES IN GML:L:PVP VEHICLE

RELEASE RATE ( $\mu\text{g/day}$ ),  $n=4$

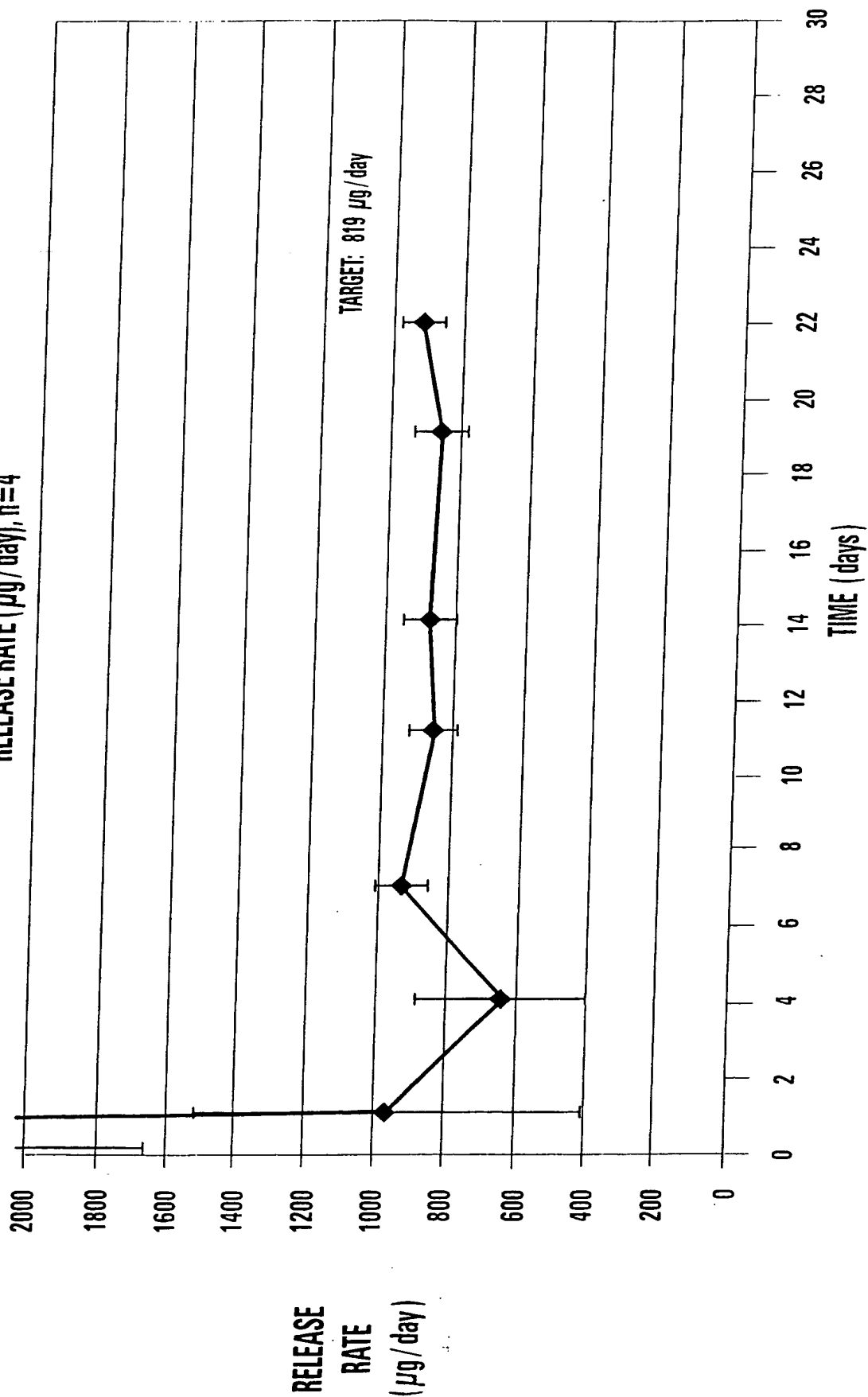


FIGURE 8

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
10 August 2000 (10.08.2000)

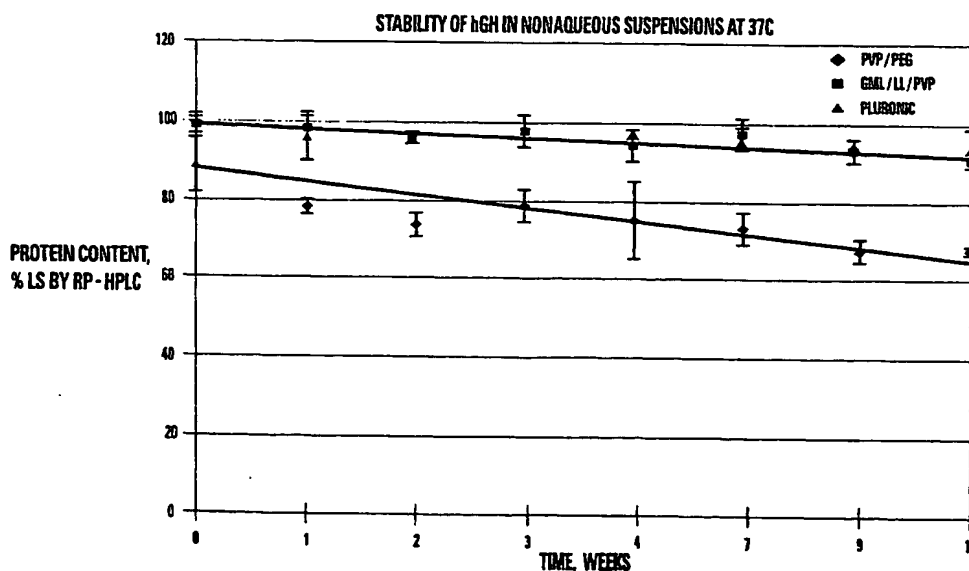
PCT

(10) International Publication Number  
**WO 00/45790 A3**

- (51) International Patent Classification<sup>7</sup>: **A61K 9/10** (74) Agents: **CLARKE, Pauline, Ann et al.**; Alza Corporation, 1900 Charleston Road, P.O. Box 7210, Mt. View, CA 94039-7210 (US).
- (21) International Application Number: **PCT/US00/02772**
- (22) International Filing Date: **2 February 2000 (02.02.2000)** (81) Designated States (*national*): AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:  
**60/119,170** **8 February 1999 (08.02.1999)** **US** (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
- (71) Applicant: **ALZA CORPORATION [US/US]**; 1900 Charleston Road, P.O. Box 7210, Mt. View, CA 94039-7210 (US).
- (72) Inventors: **BERRY, Stephen, A.**; 1050 Spring Grove Road, Hollister, CA 95023 (US). **FEREIRA, Pamela, J.**; 304 Canoe Court, Redwood City, CA 94065 (US). **DEHNAD, Houdin**; 507 Vallejo Street, El Granada, CA 94018-1325 (US). **MUCHNIK, Anna**; 1542 Winding Way, Belmont, CA 94002 (US).
- Published:  
— *With international search report.*
- (88) Date of publication of the international search report:  
**7 December 2000**

[Continued on next page]

(54) Title: **STABLE NON-AQUEOUS SINGLE PHASE VISCOUS VEHICLES AND FORMULATIONS UTILIZING SUCH VEHICLES**



(57) Abstract: This invention relates to stable non-aqueous single phase viscous vehicles and to formulations utilizing such vehicles. The formulations comprise at least one beneficial agent uniformly suspended in the vehicle. The formulation is capable of being stored at temperatures ranging from cold to body temperature for long periods of time. The formulations are capable of being uniformly delivered from drug delivery systems at an exit shear rate of between about  $1$  to  $1 \times 10^7$  reciprocal second.

WO 00/45790 A3



*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/02772

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A61K9/10

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, CHEM ABS Data, BIOSIS

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 071 642 A (SCHMERSAHL HEIN-UWE ET AL) 10 December 1991 (1991-12-10)  column 5; examples 1-4	1-7, 14-18, 21-28
X	WO 98 27962 A (ALZA CORP ; SHEN THEODORE T (US); BRODBECK KEVIN J (US)) 2 July 1998 (1998-07-02) page 7, line 3 - line 21 page 8, line 21 - page 9, line 14 page 15, line 4 - line 15	1-9, 14-38
X	WO 98 27963 A (GAYNOR DUARTE ANN T ; ALZA CORP (US); SHEN THEODORE T (US); BRODBECK) 2 July 1998 (1998-07-02) page 22, line 19 - page 23, line 14 page 25, line 12 - page 29, line 12 page 38, line 21 - page 40, line 2	1-9, 14-38
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*B\* document member of the same patent family

Date of the actual completion of the international search

5 September 2000

Date of mailing of the international search report

12/09/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3018

Authorized officer

Boulois, D

# INTERNATIONAL SEARCH REPORT

Intern      nal Application No  
PCT/US 00/02772

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 385 738 A (YAMAHIRA YOSHIYA ET AL) 31 January 1995 (1995-01-31)  column 7; examples 12,14,15	1-3,5,7, 8,14-28, 33-36,38
X	US 5 756 450 A (HAHN LORENZ ET AL) 26 May 1998 (1998-05-26) column 28 -column 29; examples 13-22	1-7, 14-32
X	US 4 734 284 A (TERADA TAKASHI ET AL) 29 March 1988 (1988-03-29) column 4; example 4	1-5, 14-25
X	WO 96 39142 A (HOFFMANN LA ROCHE) 12 December 1996 (1996-12-12) page 35; table A	1-4

## FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 1-4, 14, 15

Present claims 1-4 and 14,15 relate to an extremely large number of possible combinations of compounds, because the compounds are defined by vague terms, such as "viscous vehicle", "solvent", "polymer", or "surfactant" which encompass a great number of possibilities.

Accordingly, the initial phase of the search revealed a very large number of documents relevant to the issue of novelty, relating to these vague terms. So many documents were retrieved that it is impossible to determine which parts of the claim(s) may be said to define subject-matter for which protection might legitimately be sought (Article 6 PCT). For these reasons, a meaningful search over the whole breadth of the claim(s) is impossible. Consequently, the search has been restricted to the compositions comprising the compounds defined in the description, on page 12, line 15-page 13, line 3, and in the examples or in the figures of the present application, and a particular effort was directed to the search of implantable delivery systems, even if some documents of the search report concern only a blend of the different compounds of the compositions of the present application.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. Application No

PCT/US 00/02772

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5071642 A	10-12-1991	DE 3636123 A	05-05-1988
		AT 67677 T	15-10-1991
		DE 3773327 A	31-10-1991
		EP 0265848 A	04-05-1988
		ES 2040232 T	16-10-1993
		JP 2008687 C	11-01-1996
		JP 7037384 B	26-04-1995
		JP 63104921 A	10-05-1988
WO 9827962 A	02-07-1998	AU 5609798 A	17-07-1998
		AU 5615498 A	17-07-1998
		EP 0949905 A	20-10-1999
		EP 0959873 A	01-12-1999
		WO 9827963 A	02-07-1998
WO 9827963 A	02-07-1998	AU 5609798 A	17-07-1998
		AU 5615498 A	17-07-1998
		EP 0949905 A	20-10-1999
		EP 0959873 A	01-12-1999
		WO 9827962 A	02-07-1998
US 5385738 A	31-01-1995	JP 60084213 A	13-05-1985
		JP 1713509 C	27-11-1992
		JP 3072046 B	15-11-1991
		JP 60097918 A	31-05-1985
		JP 1803014 C	26-11-1993
		JP 5012328 B	17-02-1993
		JP 60112713 A	19-06-1985
		JP 1928128 C	12-05-1995
		JP 6057658 B	03-08-1994
		JP 61236729 A	22-10-1986
		DE 3484584 D	20-06-1991
		DE 3484951 A	26-09-1991
		DE 3486029 A	18-02-1993
		DE 3486029 T	13-05-1993
		EP 0139286 A	02-05-1985
		EP 0138216 A	24-04-1985
		EP 0140255 A	08-05-1985
		US 5021241 A	04-06-1991
		US 5081156 A	14-01-1992
		US 4774091 A	27-09-1988
		US 4855134 A	08-08-1989
		AU 587443 B	17-08-1989
		AU 5598386 A	16-10-1986
		MX 169334 B	30-06-1993
		NZ 215730 A	30-03-1988
		JP 1999987 C	08-12-1995
		JP 7025688 B	22-03-1995
		JP 62230729 A	09-10-1987
US 5756450 A	26-05-1998	AT 395819 B	25-03-1993
		AT 224988 A	15-08-1992
		AU 628787 B	24-09-1992
		AU 2217288 A	27-04-1989
		BE 1001204 A	16-08-1989
		CA 1338775 A	10-12-1996
		CH 683672 A	29-04-1994
		DE 3830494 A	23-03-1989



# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/02772

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5756450 A		DK 511188 A	16-03-1989
		ES 2012118 A	01-03-1990
		FI 884192 A,B,	16-03-1989
		FR 2620336 A	17-03-1989
		GB 2209671 A,B	24-05-1989
		GR 88100602 A,B	22-06-1989
		HU 49494 A,B	30-10-1989
		IE 61195 B	19-10-1994
		IL 87746 A	15-07-1992
		IT 1224886 B	24-10-1990
		JP 1151526 A	14-06-1989
		KR 131084 B	17-04-1998
		LU 87335 A	06-04-1989
		NL 8802275 A	03-04-1989
		NO 179434 B	01-07-1996
		NZ 226163 A	27-08-1991
		PT 88492 A,B	01-10-1988
		SE 503279 C	13-05-1996
		SE 8803221 A	16-03-1989
		ZA 8806885 A	30-05-1990
		AT 404552 B	28-12-1998
		AT 27290 A	15-05-1998
		AU 630413 B	29-10-1992
		AU 4925290 A	16-08-1990
		BE 1003009 A	22-10-1991
		CA 2009533 A	09-08-1990
		CH 679277 A	31-01-1992
		CY 1903 A	22-11-1996
		DE 4003844 A	16-08-1990
		DK 32790 A	10-08-1990
		ES 2021942 A	16-11-1991
		FI 97524 B	30-09-1996
		FR 2642650 A	10-08-1990
		GB 2230440 A,B	24-10-1990
		GR 90100076 A,B	28-06-1991
		HK 37296 A	15-03-1996
		IL 93298 A	10-06-1997
		IT 1240758 B	17-12-1993
		JP 2235817 A	18-09-1990
		KR 170769 B	01-02-1999
US 4734284 A	29-03-1988	JP 1514935 C	24-08-1989
		JP 61189230 A	22-08-1986
		JP 63066810 B	22-12-1988
		AU 583585 B	04-05-1989
		AU 5279386 A	28-08-1986
		DE 3671372 D	28-06-1990
		DK 75886 A,B,	20-08-1986
		EP 0193287 A	03-09-1986
		ES 552067 D	16-04-1987
		ES 8704727 A	01-07-1987
		HU 43953 A,B	28-01-1988
		KR 9203332 B	27-04-1992
		MX 9202976 A	01-07-1992
WO 9639142 A	12-12-1996	US 6008228 A	28-12-1999
		AU 709796 B	09-09-1999
		AU 6300496 A	24-12-1996

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/02772

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9639142 A		BG 102106 A	31-08-1998
		BR 9610842 A	13-07-1999
		CA 2224125 A	12-12-1996
		CN 1186434 A	01-07-1998
		CZ 9703803 A	18-03-1998
		EP 0831826 A	01-04-1998
		HR 960271 A	31-12-1997
		HU 9801905 A	28-05-1999
		JP 10507202 T	14-07-1998
		NO 975665 A	05-02-1998
		PL 323860 A	27-04-1998
		RO 115113 A	30-11-1999
		SK 162797 A	06-05-1998
		ZA 9604448 A	06-12-1996

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☒ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**

**THIS PAGE BLANK (USP 10,**